BREAKING BARRIERS IN LEARNING MATH

Architecture of the MILAGE Learn+ App

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ABSTRACT

The purpose of the present conference paper is to describe the conceptual framework underpinning the design of a mobile app to teach and learn math in secondary schools. The mobile learning concept is part of a societal model that assumes digital skills as vital in the ability to analyze and produce digital information, apply creative skills and innovation (technological and methodological), and engage in collaborative work. Self-directed learning and learner autonomy explicitly accept responsibility for their learning in the sense of sharing the setting of learning goals, taking initiatives in planning and executing learning activities, and regularly reviewing their learning and evaluating their goals. Mobile learning may become an autonomous activity, self-motivated, and promote informal learning or/and be part of the school experience. Counseling, self and peer-assessment, and peer-to-peer collaboration are some of the requirements underlying the design of the MILAGE Learn+ mobile app, an interactive artifact intended for learning mathematics in secondary schools.

KEYWORDS

App, mathematics, autonomous learning, technology-enhance learning, student-centered learning, educational technology.

1 INTRODUCTION

The present conference paper describes the conceptual framework underpinning the design of a mobile app to teach and learn math in secondary schools. In the last decade, new technologies have emerged and new educational environments have been created which make we think in new ways to teach and learn. The mobile learning concept is part of a societal model that assumes digital skills as vital in this second decade of the XXI century. We refer to, in particular, the ability to (1) analyze and produce digital information where and when the user wants, (2) make decisions in the context of an information society, (3) apply creative skills and innovation (technological and methodological), (4) engage in collaborative work and (5) master an operational knowledge of digital media and global communications.

In these new environments, the research moves beyond simply observing and actually involves systematically engineering learning contexts in ways that allow us to improve and generate evidence-based assertions about learning. Coherent and integrated tools, content-based curriculum, and pedagogical models that help teachers systematically understand, predict and design how learning occurs in new learning scenarios are needed to cope with and benefit from the changing circumstances. Furthermore, it makes sense to consider the integration of mobile learning in systems managed by students, allowing them to set personal goals, manage content and communicate with each other. In practice, these Personal Learning Environments (PLEs) are made up of several components, which may include social networks, virtual worlds and authoring software, interconnecting various learning resources suitable to the pedagogical contexts and skills to be acquired by each learner.

Precisely for this reason in this paper we examine the architecture and theoretical requirements underlying the design of the MILAGE Learn+ mobile app, an interactive artifact intended for learning mathematics in secondary schools.

2 AUTONOMOUS WORK AS AN ATTITUDE

Mobile pedagogy is founded on the belief that mobile devices can support self-directed learning and learner autonomy. Learning maths through mobile devices is not simply the transfer of current teaching and learning materials and the practice to mobile device, but it is a complete reconceptualization of these.

For that, this mobile application supports not only content but also explores opportunities to promote communication and collaboration among users.

There is much discussion around the term autonomous learner but there is general agreement, broadly speaking, that autonomous learners understand the purpose of their learning program, explicitly accept responsibility for their learning, share the setting of learning goals, take initiatives in planning and executing learning activities, and regularly review their learning and evaluate its effectiveness [1].

According with Lee and Hannafin [2] to imply autonomy in the student-centered learning framework, it is important to ensure that students own their learning processes. Students mediate learning processes when they determine and accomplish learning goals; Teachers, in effect, should support student autonomy because it promotes students' engagement, concentration, better time management, self-regulation, and higher performance [3, 4].

Thus, learner autonomy does not mean independence. It is a holistic view of the learner that requires him to engage with the cognitive, metacognitive, affective and social dimensions of learning. In other words, there is a consensus that the practice of learner autonomy requires insight, a positive attitude, a capacity for reflection, and a readiness to be proactive in self-management and in interaction with others.

However, autonomous learning and effective self-regulatory strategies are very important in learning; without these, students might not be able to exploit learning opportunities outside classrooms. For that, an important way of supporting learning autonomy is promoting student-centered learning approaches to encourage and engage learners in decision-making, and get them involved with the processes of learning during and between lessons.

Lee and Hannafin designed a framework for enhancing engagement in student-centered learning pointing out that:

> Students maintain personal responsibility for learning as they utilize external resources. Autonomy supports two roles in student-centered learning: sovereignty and responsibility. In terms of sovereignty, students assume the power and control to determine learning goals, decisions, and actions required to achieve those goals. When encouraged to make decisions, students perceive it as taking control of their learning and develop personal ownership. For responsibility, students become accountable for the consequences of their goals, decisions, and actions. They assume responsibility for managing their learning processes and project completion. [2], p. 715.

Deci and Ryan [5] agree that students perceive autonomy in their learning when teachers support their interests, preferences, values, and psychological needs. Supportive learning environments provide more confidence on how assignments are designed; provide opportunities to make individually relevant and interesting choices, so students express their own needs and integrate them into the classroom activities; allow time to work on a problem in individual ways. [2]

Therefore, some studies investigated the influence of motivational factors and self-regulatory strategies on autonomous learning behavior [6]. According to Dörnyei [7] motivation could explain why people select a particular activity, how long they are willing to persist in it, and what effort they invest in it. So successful learning performance go hand in hand due to internal or/and external motivation.

Another aspect to consider is learning on demand. It is becoming a type of lifestyle in modern society [8]. Thus, learners should not be considered as passive information consumers rather than active co-producers of content. Smartphones are suitable platforms that perform many of the functions of a computer, for example, they have a touchscreen interface, and there are tools to record audio and video, take pictures, make digital editing, with easy internet access and sharing of content, among others. Therefore, perhaps teachers should let students explore learning opportunities outside classrooms, as this could be a great practice to promote autonomous learning in mobile contexts.

To sum up, there are several assumptions to consider in learning autonomy: self-regulatory strategies to learn, learning effort, autonomous learning behavior, motivational orientation, counseling, peer-to-peer collaboration, among other. For that, encouraging learner autonomy and independent learning are crucial factors to enable successful learning. Additionally, mobile learning may become an autonomous activity, self-motivated, and promote informal learning or/and be part of the school experience.

3 SELF AND PEER-ASSESSMENT

Educational assessment is essential to student learning and constitutes an integral part of the teaching and learning process. It is argued that with the emergence of new media, educational processes should adopt new assessment practices that would respond to new knowledge-building practices and involve the use of new technologies [9]. Two aspects emerge here as factors determining the direction of change or modification of traditional approaches to assessment: human factor related to new forms of knowledge work and human-technological factor related to new forms of social communication and interaction. New forms of knowledge work require individual engagement and collective responsibility [10]. Also, new forms of social communication and interaction involve social use of new digital environments. These factors are not without educational implications.

In the contemporary educational landscape, the balance of agency is shifting from the knowledge authority of a teacher towards learner subjectivity in the learning process. This sort of subjectivity is to be an instrument to achieve effectiveness in the world in which workplaces rely on teamwork and self-motivating work culture. In the New Learning concept, learners should be assuming a greater share of responsibility for their learning and each other. In the 21st century learners are expected to be as much makers of their own knowledge as the receivers of it [11].

Changing conceptions of education emphasize the importance of active participation in learning process including assessment.

Important activities that support active learning require abilities to predict one's performance on various tasks and monitoring current level of mastery and understanding. These skills fall under the heading of "metacognition". "Teaching practices congruent with meta-cognitive approach to learning include those that focus on sense-making, self-assessment and reflection" [12]. These practices engage students in making judgments about learning process enriching learning experience and lifting it to active and participatory level.

Self-assessment is defined as a process of formative assessment requiring students to reflect on and evaluate the quality of their work and their learning. This process involves identification of strengths and weaknesses of one's work followed by the necessary revision [13]. Peer assessment requires students to provide either feedback or grades (or both) to their peers on a product or a performance, based on the defined marks, which students may have been involved in determining[14]. Both self and peer-assessment recognize learners as active participants in their learning processes and contribute to establishing a culture of engagement and support.

Self and peer assessment promote formative learning, learners' responsibility and learners' independence. Increased level of responsibility and autonomy lifts the role of a student from passive to active, which may result in a deeper approach to learning. Self-assessment is linked with introspection and self-discovery while peer-assessment adds a cooperative atmosphere to the learning. The list of advantages includes development of deeper understanding of the subject matter and fostering skills for lifelong learning crucial in knowledge societies.

Disadvantages may include risk with respect to reliability of assessment, risk of personal bias and reluctance to make judgment. Whether disadvantages outweigh advantages is a matter for discussion, subject to the question of what we want to achieve by giving students an active role in the assessment process. In a broader sociocultural perspective, "peer" dimension in educational assessment encourages students to reflect on their roles and contributions, an important aspect of collaborative work and civic engagement. In a broader cognitive perspective, the "self" dimension helps the development of students' judgment skills, an outcome of transversal quality applicable to a broad range of various literacies. Both perspectives, combined with the philosophy of participatory culture, justify serious considerations in favor of involving students as active agents in an assessment process. These perspectives were determinant in the instructional design supported by the MILAGE Learn+ App.

4 MILAGE LEARN+ APP

MILAGE Learn + [15] is an open and free mobile app. It is possible to download it from Google play and App Store. The design of the app has been developed within the MILAGE Project – Interactive Mathematics by Implementing a Blended-learning Model with Augmented Reality and Game Book (2015-2018). This resource shares the same interface within the four countries that participate actively in the project, and it has also been translated in four languages: Portuguesse, Norwegian, Spanish and Turkish.

The app has an intuitive interface, where the user can independently access all the resources that have been elaborated carefully by teachers and students on different courses in secondary schools. All resources were organized by topics according to the 10th, 11th and 12nd official Math curriculum of each country.

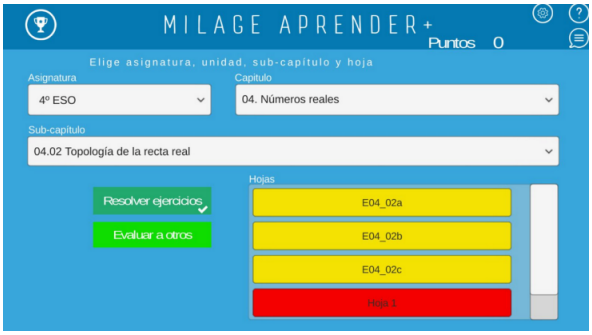

Figure 1: Interface MILAGE Learn+ App

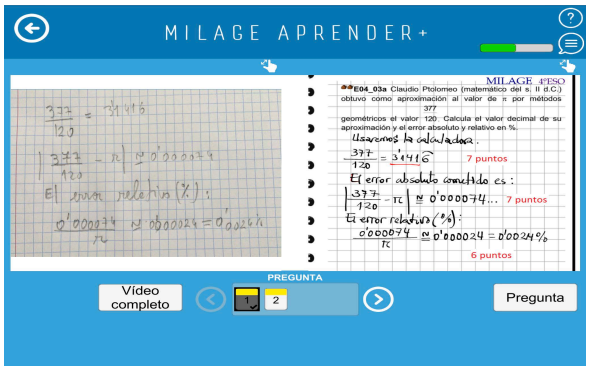

Figure 2: Autonomous design architecture MILAGE Learn+

The main function of teachers and professors, at secondary schools and universities, has been to develop a general framework to design materials. Firstly, they designed eBook content in EPUB format; secondly, videos were recorded; thirdly, videos, templates, and voices were added to the layout; and finally, a gamification system was designed to enhance peer-to-peer and self assessment. Students from secondary schools have been integrated as an active part of the project in specific tasks such as the recording of the voices that are integrated in the videos. We realized that students were more involved into their learning when they recognized their voices and their colleagues' voices. Students also feel more identified with other classmates in the

way they expressed themselves, and they understand better how to solve a problem if it is explained by another student.

The content was organized in courses and topics with different levels of difficulty. The process was designed to enhance autonomous learning.

Therefore, each app user first chooses the problem to solve according to his own learning needs. Once solved, the student takes a picture of the solution proposal and uploads this. After that, the student can visualize the video recorded previously by teachers, where he can find the correct math process and problem solution. If the the solution proposed by a student is the same as the solution proposed by teachers, the student can get the maximum of points in the resolution template assigned to the exercise. If not, a student will have to reconsider and rethink how many points could gain according with the instructions that teachers point out in the resolution template. To avoid that students assign the maximum number of points for no reason, a peer-to-peer assessment is possible. It consists of a penalization to students that do not solve the problem correctly and give themselves extra points. At the same time, the user that reviews other students work can get a reward that makes him get a better position in the learning community.

This good practice is constantly under development and improvement. The learning that is promoted by the app is more authentic and more useful for the users because they are involved in the creation of videos, so they can use the app any time and anywhere, and they are also encouraged to use the app to reinforce and improve performance in mathematics. The student can self-regulate learning according to his needs, take advantage of more flexible learning methods, play different roles, customize his learning and solve problems according to different degrees of difficulty.

Therefore, students take control of their own learning and at the same time they learn with technology. The introduction of gamification elements identified by S. H. Hsu, J.W. Chang, and C.C. Lee [16] motivate and maintain the interest of users. Achievements and levels of expertise are motivated by the need to achieve objectives and goals through solving problems in an iterative way. To achieve that the app includes elements such as rewards, goals, levels and a score board within the game. The interpersonal relationships in the app are supported by the possibility of using a chat incorporated in the application, where users can connect with each other, learn, collaborate and establish altruistic relationships.

5 CONCLUSION

This app model has been tested in real learning environments in all the countries that participated in the project. The app was successfully implemented and it was a fruitful experience for our students and also for teachers. However, we realized that we have to improved some elements of the architecture in terms of functionality and design to get a mature model.

We also realized that this app can be used, not only to teach maths, but also to teach other subjets. In Portugal, for example, this app has been used to teach other subjets, for example, informatics, languages, and other with positive impact.

The MILAGE Learn+ app, as mobile technology, also converges with cultural practices that transform learning and have an effect outside the formal institutions. This mobile technology broadens the scope of teaching and enables new learning contexts within common educational practices.

To sum up, mobile devices with Internet connection change the way to access the information, to consume content in informal contexts, to promote active methodologies with focus on students, and to open new ways for virtual interaction. This app provides the possibility for learning math anytime and anywhere, carrying only a mobile device in the pocket. The gamification elements introduced in app were essential to rethink how students learn, and how learners follow new learning patterns and become more autonomous.

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REFERENCES

[1] H. Holec. 1981. *Autonomy and Foreign Language Learning*. Pergamon, Oxford.

[2] E. Lee and M. J. Hannafin. 2016. *A design framework for enhancing engagement in student-centered learning: own it, learn it, and share it*. Educational Technology Research and Development, vol. 64, no. 4, 707- 734.

[3] H. Jang, J. Reeve, and E. L. Deci. 2010. *Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure.* Journal of Educational Psychology, vol. 102, no. 3, 588–600.

[4] J. Reeve. 2006. *Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit*. The Elementary School Journal, vol. 106, no. 3, 225–236.

[5] E. L. Deci, and R. M. Ryan. 2000. *"The'' what'' and'' why'' of goal pursuits: Human needs and the self-determination of behavior*. Psychological Inquiry, vol. 11, no. 4, 227–268.

[6] J. Kormos and K. Csizér. 2014. *The Interaction of Motivation, Self-Regulatory Strategies, and Autonomous Learning Behavior in Different Learner Groups*. Tesol quarterly, vol. 48, no. 2, 275-299.

[7] Z. Dörnyei. 2001. *Teaching and researching motivation*. Longman, London, England.

[8] C. McLoughlin and M. J. W. Lee. 2010. *Personalised and self-regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software*. Australasian Journal of Educational Technology, vol. 26, no. 1, 28-43.

[9] Ch. Fadel, M. Honey, and S. Pasnik. 2007. *Assessment in the Age of Innovation*. Educational Week. Retrieved from http://www.edweek.org/ew/articles/2007/05/23/38fadel.h26.html

[10] M. Scardamalia. 2002. Collective Cognitive Responsibility for the Advancement of Knowledge. In *Liberal Education in a Knowledge Society* (B. Smith, ed.), 67-98, Open Court, Chicago.

[11] M. Kalantzis and B. Cope. 2008. *New Learning: Elements of a Science of Education*. Cambridge University Press, New York.

[12] J.D. Bransford, A.L. Brown, and R.R. Cocking. 2000. *How People Learn.*: National Academy Press, Washington D.C..
[13] H. Andrade and Y. Du. 2007. *Student responses to criteria-referenced self-assessment.* Assessment and Evaluation in Higher Education, vol. 32, no. 2, 159-181.
[14] D. Boud and N. Falchikov. 2007. *Rethinking assessment in higher education.* Kogan Page, London.
[15] Figueiredo, M. J.G., Godejord, B., & Rodrigues, J.I. 2016. The Development of an Interactive Mathematics APP for Mobile Learning. 12th International Conference on Mobile Learning 2016, Vilamoura, Portugal, 9-11 April, pp. 75-81.
[16] S. H. Hsu, J.W. Chang, and C.C. Lee. 2013. *Designing attractive gamification features for collaborative storytelling websites.* Cyberpsychology, Behavior, and Social Networking, 16(6), 428-435.